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Activated carbon enhancement with covalent organic polymers: An innovative material for application in water purification and carbon dioxide capture

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Covalent organic polymers (COPs) have emerged as one of the leading advanced materials for environmental applications, such as the capture and recovery of carbon dioxide and the removal of contaminants from polluted water.^{1–4} COPs exhibit many remarkable properties that other leading advanced materials do not all-encompassing possess. Moreover, COPs have proven to be extremely stable in a wide variety of conditions, i.e. extremely high temperatures and boiling water for weeks at a time, which make them ideal for environmental applications;¹ ranging from CO₂ capture and recovery to organic solvent uptake in concentrated streams to metal and organic pollutant adsorption in contaminated waters.² However, given the nanoscale structure of these COPs, real-world application has yet remained elusive for these materials. By creating a material large and robust enough to be used in a full-scale operation, and by retaining the unique properties that only nanomaterials can offer; this novel class of carbon-based materials promises to be a practical and efficient solution to many environmental applications. Herein, we report the functionalization of COPs onto the surface of activated carbon granules; through a series of surface modification techniques, followed by the synthesis of a COP “shell” around the carbon granule. Activated carbon, established as one of the cheapest, robust, and most effective environmental remediation materials of all time, provides the ideal base material for the grafting of COPs onto a material large enough to be able to be used in a packed-bed column. These columns can then be applied in biogas purification to remove CO₂ and up-concentrate methane, in the exhaust flue gas stream from a power plant. Furthermore, by impregnating nanoscale zero valent iron (nZVI) inside the COP matrix, these columns can subsequently degrade organic contaminants, e.g. halogenated solvents, azo dyes, antibiotics, etc., during the water treatment process as a flow-through water treatment column that can synergistically adsorb and degrade various pollutants in various water sources. A first of its kind, activated carbon with a COP-functionalized shell provides a robust and regenerate-able material with the durability and versatility for a wide range of environmental applications.

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